NASA Procedural Requirements

NPR 1800.1A
Effective Date: August 02, 2006
Expiration Date: October 31, 2008

COMPLIANCE IS MANDATORY

Printable Format (PDF)

Subject: NASA Occupational Health Program Procedures

Responsible Office: Office of the Chief Health & Medical Officer

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Chapter 4. Environmental Health

4.1 Regulatory Compliance

4.1.1 Introduction

NASA Centers must comply with applicable OSHA standards promulgated under Section 6 of the OSHA Act of 1970. Exceptions may be made in the case of Alternate or Supplementary Standards, provided those standards were developed in accordance with 29 CFR 1960.17 and 1960.18, respectively. Additionally, NASA may develop specific standards in instances in which a NASA program is intended to clearly exceed the protection offered by compliance to an OSHA Standard.

4.1.2 Responsibilities

a. NASA Center OHP personnel are responsible for providing occupational health support that complies with OSHA regulations. If a unique NASA operation requires the need for an alternate or supplementary standard, Center OHP personnel are responsible for identifying that need and proposing and submitting the necessary alternate or supplementary standard with all necessary supporting documentation. If the alternate/supplementary standard is approved, Center OHP personnel must implement it.

b. Center Directors must ensure that their Center OHP complies with all applicable standards and regulations.

c. The NASA OHP provides coordination and communication with the NASA Centers and provides technical and subject matter expertise.

d. The Designated Agency Safety and Health Officer (DASHO, i.e., the NASA Chief Health and Medical Officer) serves as the Headquarters coordinator for review of alternate and supplementary standards and prepares necessary material for interagency review with the Department of Labor.The DASHO, or designee, also coordinates Agencywide and interagency reviews and approval and may publish the standards in their final form.

4.1.3 Process Description

a. Approval for variances from OSHA standards may be obtained by submitting the proposed alternate or supplementary standards to the DASHO for coordination and approval by the Secretary of Labor. Alternate or supplementary standards are normally adopted as NASA-wide standards.

b. Approval for variances from NASA standards will be accomplished per variance guidelines in NPR 8715.3. NASA Safety Manual, Paragraph 1.20,Safety Risk Acceptance Variance Process. Nonconformance with unique NASA-developed standards for which there are no OSHA standards will only require approval within NASA.

c. Alternate Standards:

NASA may develop unique alternate health standards provided such standards are approved in accordance with CFR 1960.17.The DASHO serves as the Headquarters coordinator for review of alternate standards and prepares necessary material for interagency review with the Department of Labor. Requests for alternate standards are coordinated with employees or their representatives and are not approved unless the alternate standard provides

equivalent or greater protection for affected employees.

d. In developing and submitting alternate standards, NASA shall provide the following information:

(1) A statement as to why NASA cannot comply with the OSHA standard or wants to adopt an alternate standard.

(2) The proposed alternate standard.

(3) An explanation of how the alternate standard provides equivalent or greater protection for the affected employees.

(4) A description of interim protective measures employed pending approval of the standard.

(5) A written summary of comments, if any, from interested employees, their representatives, or the applicable safety and health committee.

e. Supplementary Standards:

Unique NASA operations, materials, facilities, equipment, procedures, and practices may require establishment of supplementary health standards. NASA may develop unique supplementary health standards, when no OSHA standard or Voluntary Consensus Standard exists, provided such standards are approved in accordance with CFR 1960.18. When a standard is applicable NASA-wide, the standard is issued as a NASA health standard. The NASA organization proposing the supplementary standard acts as the lead in developing the standard. The DASHO coordinates Agencywide and interagency reviews and approval and may publish the standard in its final form.

f. In developing and submitting supplementary standards, NASA shall provide the following information:

(1) A statement as to why NASA requires the development of the supplementary standard.

(2) The proposed supplementary standard.

(3) An explanation of how the supplementary standard provides protection for the affected employees.

(4) A description of interim protective measures employed pending approval of the standard.

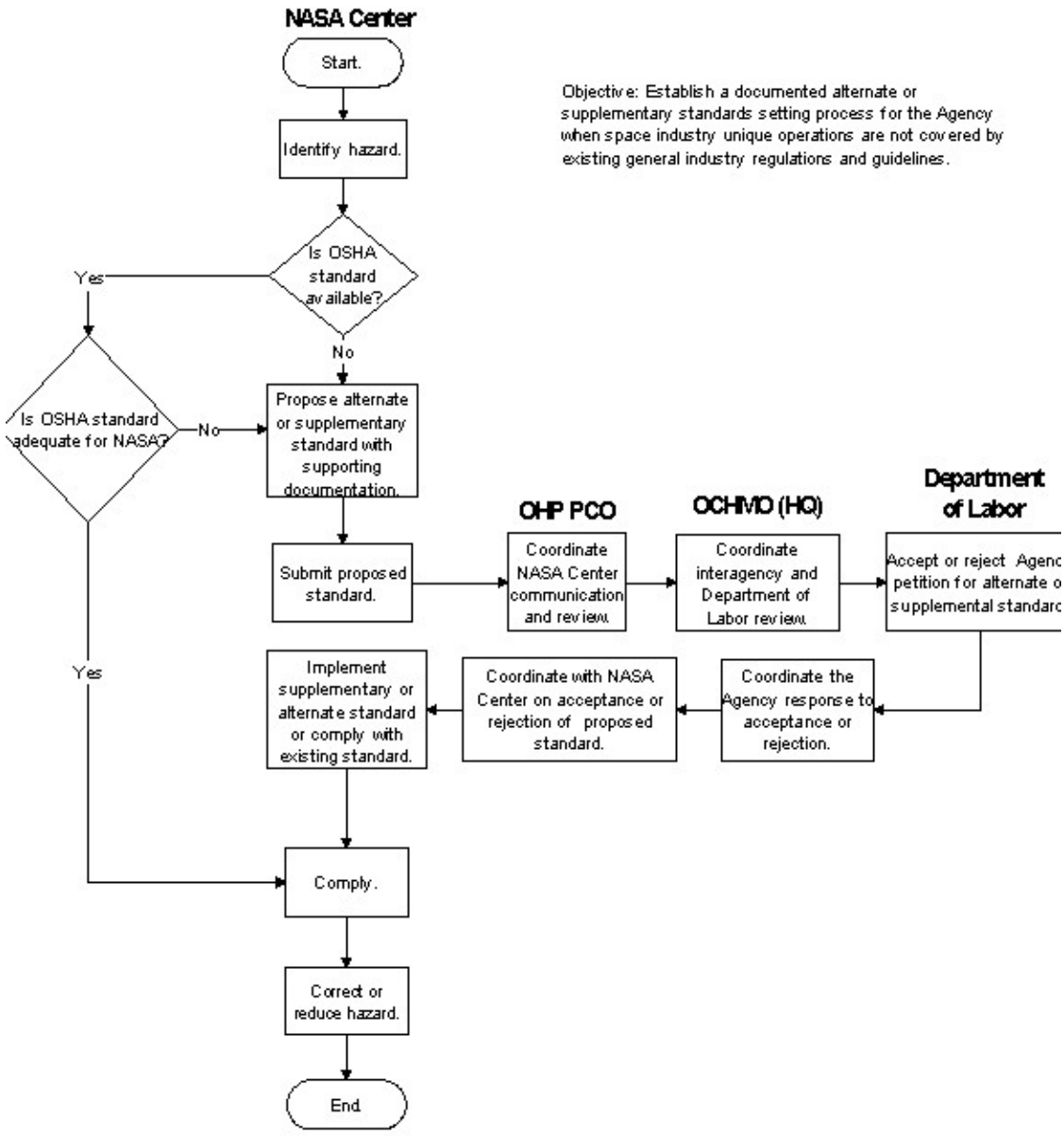
(5) A written summary of comments, if any, from interested employees, their representatives, or the applicable safety and health committee.

(6) A Center applying for Voluntary Protection Program (VPP) will inform the DASHO by letter of the Center's intent.

4.1.4 Flow Diagram

The flow diagram for this process is shown in Figure at the end of this section.

4.1 Regulatory Compliance



4.2 Occupational Exposure Assessment and Management

4.2.1 Introduction

The role of industrial hygiene is to anticipate, recognize, evaluate, and control health hazards in the workplace. An effective and proactive mechanism to fill this role and to manage industrial hygiene programs is to employ a systematic and comprehensive approach to exposure assessment. A comprehensive approach results in a thorough understanding of exposures and enables the industrial hygienist to establish priorities for the program. This allows the program to better protect employees and manage exposure related risk. It also places the program in a better position to anticipate and manage unpredictable changes that can occur and enables the more efficient utilization of resources.

4.2.2 Responsibilities

a. NASA Center Directors have the responsibility for implementing and operating environmental health programs at their respective Centers in full compliance with the following:

(1) NPD 1800.2A, NASA Occupational Health Program, January 16, 2001.

(2) NPD 1820.1A, NASA Environmental Health Program, January 16, 2001.

(3) NPD 1810.2A, NASA Occupational Medicine Program, January 16, 2001.

b. This includes establishing effective organizations to fulfill environmental health requirements using professionally qualified persons and allocating resources for the Environmental Health Program, and ensuring that Center managers and other personnel cooperate with Environmental Health personnel in meeting the requirements of the program and other applicable health policies, standards, and guidelines.

c. NASA Center Environmental Health personnel shall perform the following:

(1) Establish and direct the exposure assessment program.

(2) Assure key competencies.

(3) Review assessment conducted by other staff.

(4) Direct follow up efforts.

(5) Manage the regular monitoring program.

(6) Develop a Management of Change system.

(7) Use other knowledgeable personnel and additional experts when required.

(8) Evaluate the background systems.

(9) Identify personnel requiring surveillance.

d. NASA Center Occupational Medicine personnel shall perform the following:

(1) Provide health surveillance screening to identify any workers or worker groups who may be at an elevated occupational health risk

(2) Work with other functions to assure such workers' exposures have been assessed and control measure decisions made and adopted, as necessary.

4.2.3 Process Description

a. Establishment of the Exposure Assessment Strategy

(1) Purpose:
To begin the process by establishing a strategy for exposure assessment.

(2) Outcome

(i) Written exposure assessment program.

(ii) Defined goals for the exposure assessment program.

(iii) Defined roles for the participants.

b. Basic Characterization

(1) Purpose
To collect and organize available information on the workplace; workforce; chemical, physical, and biological agents; existing controls; historical exposure data; biological monitoring data; and any other available source of information.

(2) Outcome
A complete summary of available essential information on workers, tasks, agents, potential exposures, and potential health effects.

c. Exposure Assessment

(1) Purpose
To interpret available information to define exposure groups.

(2) Outcome

(i) List of similar exposure groups.

(ii) Each worker is a member of at least one exposure group.

d. Defining and Judging Exposure Profiles

(1) Purpose

(i) To define exposure profiles for the identified exposure groups.

(ii) To make judgments about the acceptability of the exposure profiles.

(2) Outcome

(i) Exposure profile for each exposure group.

(ii) Judgment about the acceptability and the uncertainty of the exposure profile for each exposure group.

(iii) A determination that, generally, the exposure is either uncertain, unacceptable, or acceptable. Uncertain exposures lead to further information gathering. Unacceptable exposures lead to control of the exposure. Acceptable exposures lead to a programmed reassessment.

e. Further Information Gathering

(1) Purpose

(i) To set priority on exposure groups for further information gathering.

(ii) To gather or generate additional qualitative or quantitative information so that exposure groups can be better characterized and/or the risk posed by the exposure better understood.

(2) Outcome
Information and/or data that can be used to enhance the basic characterization and better define exposure groups, their profile, and the risk posed by the exposure profile.

f. *Quantitative Exposure Data*

If monitoring data are collected, statistical tools can be used to aid in understanding the data and to assist in interpretation and decisionmaking. The theoretical basis and limitations of the statistical tools used must be understood by the person using them. The goal should be to ensure as much as possible that measurements are collected randomly and that data reasonably conform to the appropriate distribution.

g. *Control of Unacceptable Exposures*

(1) Purpose

(i) Prioritize exposure groups with unacceptable exposures for control.

(ii) Develop strategy for control.

(iii) Protect workers while long-term controls are put in place.

(2) Outcome

(i) Prioritized control plan.

(ii) Short term and long term control options.

(iii) Exposures controlled.

h. Reassessment

(1) Purpose

(i) Periodically recharacterize and reassess exposures in order to--

(ii) Update exposure groups and exposure profiles,

(iii) Identify changes that may influence exposures,

(iv) Identify unacceptable exposures for control,

(v) Identify uncertain exposures for further information gathering.

(2) Outcome

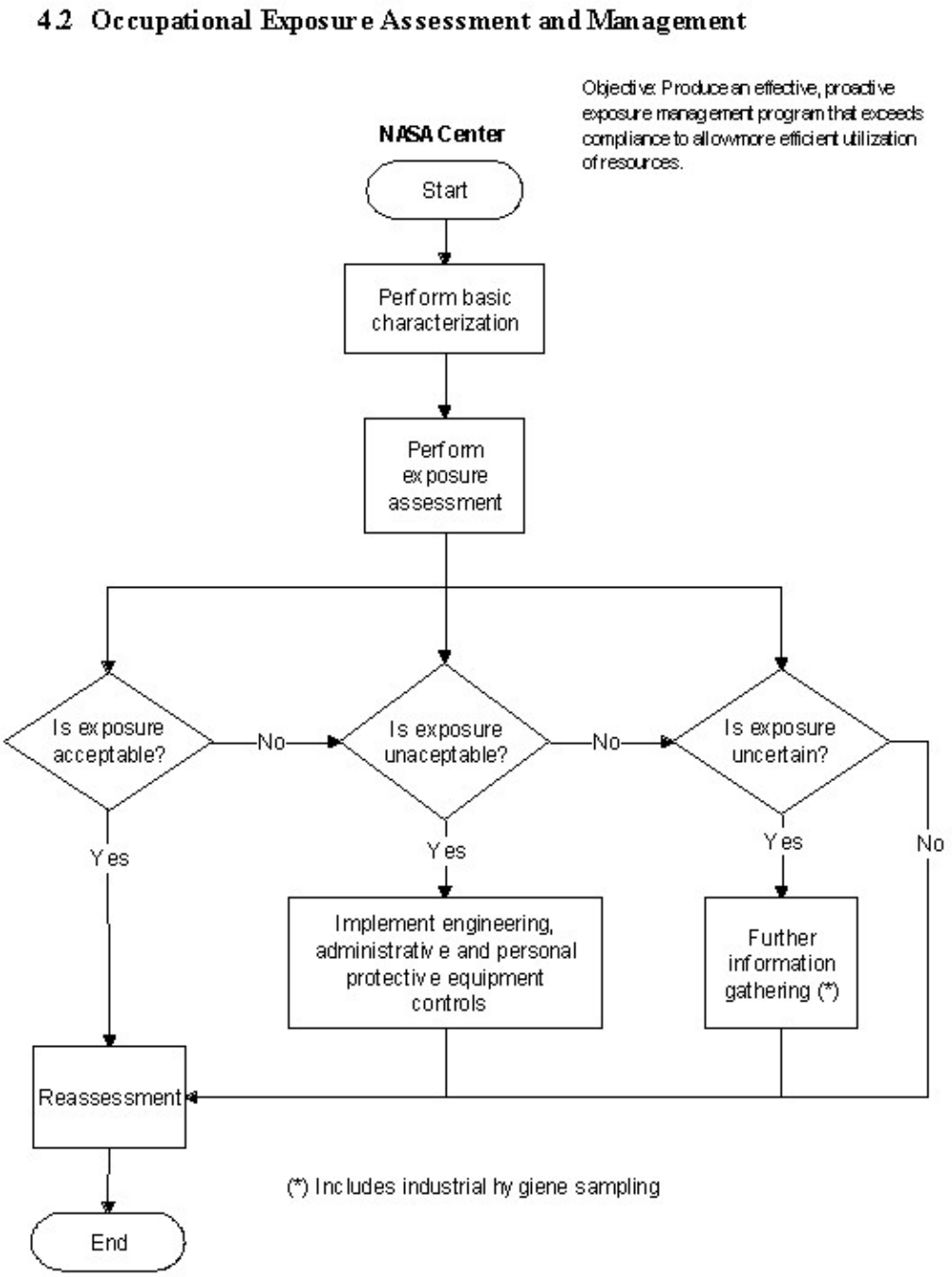
(i) Prioritized schedule for reevaluation.

(ii) Updated basic workplace characterization.

(iii) Updated exposure groups and exposure profiles.

4.2.4 Flow Diagram

The flow diagram for this process is shown in Figure 4.2 at the end of this section.



4.3 Occupational Exposure Limits

4.3.1 Introduction

a. The NASA OHP ensures that NASA employees are provided with a healthful workplace environment that is free from harmful levels of exposure to toxic or hazardous chemical, physical, and biological agents. To that end, NASA complies with applicable regulations of other Federal agencies, as well as NASA's health and safety requirements. In the event of conflicting standards or regulatory issuance, the more protective requirements shall be met, until otherwise determined acceptable by an authorized and competent individual (e.g., Certified Industrial Hygienist).

b. NASA follows, at a minimum, all OSHA standards promulgated under Section 6 of the OSHA Act of 1970. These standards include the PEL's for hazardous airborne contaminants identified in 29 CFR 1910 Subpart Z. While the OSHA PEL's carry the weight of law, the majority of them were adopted in 1970 from 1968 consensus values and

do not necessarily reflect current scientific data. Additionally, there are currently PEL's established for approximately 400 chemicals. This is a relatively small percentage of the thousands of chemicals that exist. For these reasons Occupational Exposure Limits (OEL) recommended and established by other acknowledged authorities must be considered in order to fully protect NASA's workforce. OEL's, even those carrying the force of law, are not boundaries between safe and unsafe. Always staying below the limit does not guarantee good health for all workers, nor does going above the limit mean that workers will necessarily experience injurious effects. The proper implementation of OEL's requires people with appropriate training to continually observe and monitor both the employees and the work environment.

4.3.2 Responsibilities

a. NASA Center Directors are responsible for implementing and operating environmental health programs in full compliance with NPD 1820.1, NASA Environmental Health Program, and in conjunction with NPD's 1800.2, NASA Occupational Health Program, and 8710.2C, NASA Safety and Health Program Policy. This includes establishing effective organizations to fulfill environmental health requirements using professionally qualified persons, allotting resources for the Environmental Health Program, and ensuring that Center managers and other personnel cooperate with Environmental Health personnel in meeting the requirements of the program and other applicable health policies, standards, and guidelines.

b. NASA Center Environmental Health managers or their designees are responsible for monitoring the workplace and the workforce and to select the most appropriate and protective OEL's. They are also responsible for developing and recommending OEL's in the absence of an existing OEL for a specific chemical.

c. The NASA OHP provides technical support to NASA Centers in developing OEL's where none exist. Support may, for example, be in the form of reference materials, literature searches, and consultation with experts.

4.3.3 Process Description

a. NASA utilizes OSHA PEL's, Threshold Limit Values (TLV) issued by the American Conference of Governmental Industrial Hygienists or specific NASA Health Standards issued by the OHP, whichever is more stringent

b. In the absence of a specific PEL, TLV, or NASA Standard, other sources of OEL's may be utilized. These include the following:

(1) National Institute for Occupational Safety & Health Recommended Exposure Limit.

(2) American National Standards Institute Standards.

(3) National Academy of Science Recommendations.

(4) American Industrial Hygiene Association Workplace Environmental Exposure Level.

(5) Environmental Protection Agency Recommendations.

(6) Deutsche Forschungsgemeinschaft (German Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area) Maximum Allowable Concentration.

(7) British Health & Safety Commission and Health & Safety Executive. Occupational Exposure Limits.

(8) Chemical Manufacturers.

c. When no established OEL exists for a specific chemical, a working OEL may be established after a thorough examination of the data available for that chemical and by following established industrial hygiene exposure limit setting guidelines. While setting OEL's is not an exact science, it does require knowledge, experience, and professional judgment and shall only be undertaken by professionals that possess the appropriate degree of each (e.g., a Certified Industrial Hygienist). This process shall take into account chemical analogy, animal experimentation and extrapolation, and human experience and epidemiological data. Important data to be considered include but are not limited to the following:

(1) Thorough identification of the hazard.

(2) Routes of exposure.

(3) Chemical specific toxicology data.

(4) Physical and chemical properties.

(5) Acute toxicity and irritation data.

(6) Sensitization studies.

(7) Metabolism and pharmacokinetics.

(8) Genotoxicity.

(9) Reproductive and developmental toxicity.

(10) Neurotoxicity.

(11) Subacute/subchronic toxicity.

(12) Chronic toxicity and oncogenicity.

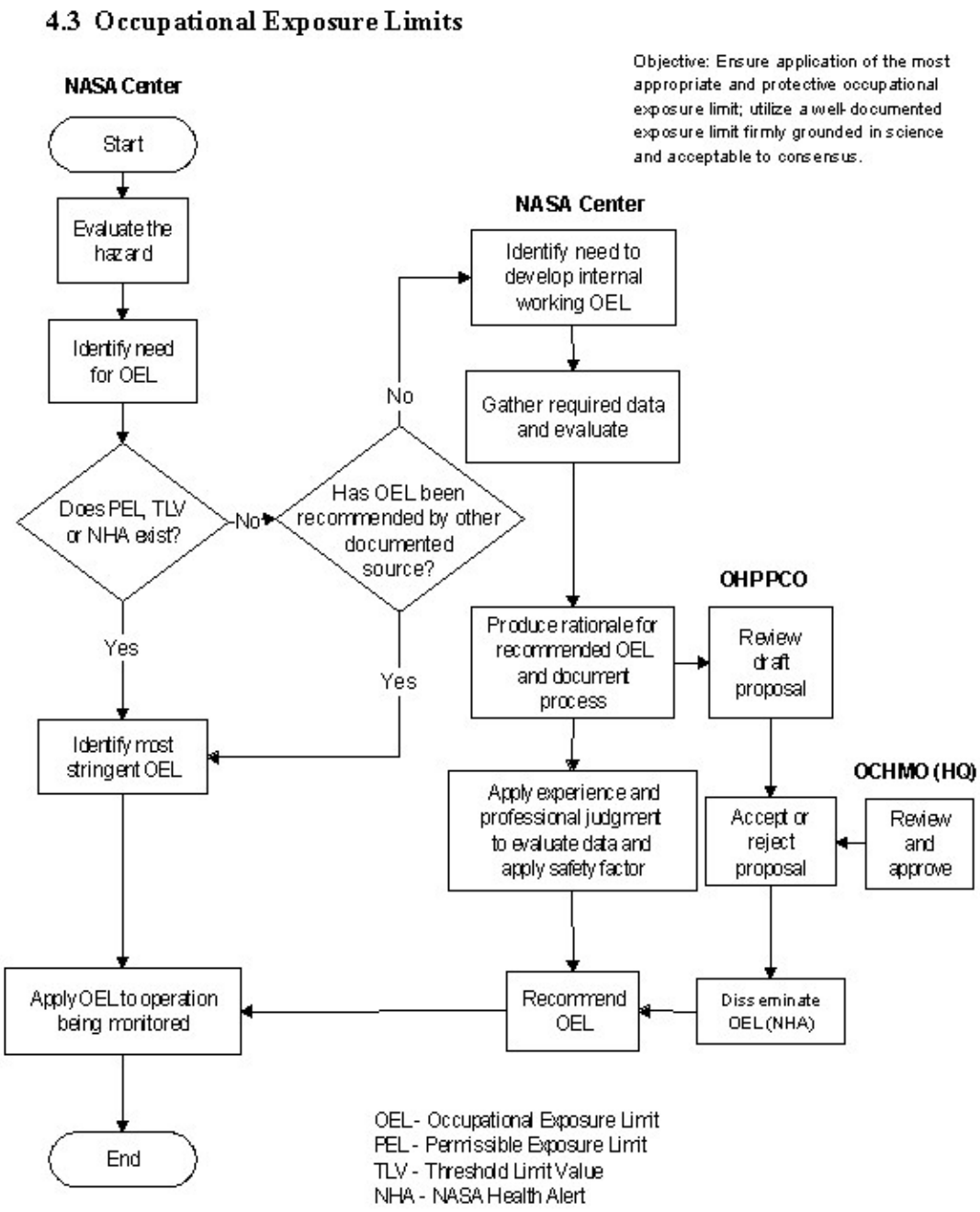
(13) Human use and experience.

(14) Scientific references.

d. All of the available data shall be thoroughly documented. A written rationale that considers, summarizes, and weighs the importance of all data shall be produced. Additionally, experience and professional judgment shall be applied to weigh all information and apply an appropriate safety factor, based on the strength of the available data before an OEL is recommended.

4.3.4 Flow Diagram

The flow diagram for this process is shown in Figure 4.3 at the end of this section.



4.4 Sampling and Analytical Methods and Equipment Calibration

4.4.1 Introduction

To provide environmental health personnel at NASA Centers with the necessary reference material to perform their job, the NASA OHP has provided a primer on air sampling and equipment calibration. This primer is not intended to take the place of any learned or established methods currently utilized by environmental health personal but as a reference method for those areas that the environmental health professional might not be familiar with or has not worked in recently.

4.4.2 Responsibilities

a. NASA Centers are responsible for providing training and equipment necessary to their environmental health personnel so that they may perform their jobs in an effective manner.

b. The NASA OHP assesses the quality and consistency of OHP activities and assists with developing resource needs.

4.4.3 Process Description

a. The Sampling and Analytical Methods and Equipment Calibration primer follows accepted practice but may use Center individualization. The guide covers such areas as the following:

(1) Presurvey activities.

(2) Work area walkthroughs.

(3) Records review.

(4) Sample planning.

(5) Performance of the survey.

(6) Collection of bulk samples.

(7) Ventilation assessment.

(8) Shipment of sampling media.

(9) Sampling methodology.

(10) Sample recording form

b. If a sample exceeds standard value, engineering, administrative and personal protective equipment controls will be applied as appropriate followed by resampling. All results will be recorded and maintained as per OSHA and NASA record keeping requirements.

4.4.4 References

a. OHP Web site at http://ohp.nasa.gov for the actual Sampling and Analytical Methods and Equipment Calibration primer and any of the below referenced material for further explanation of analysis or methods.

b. Manual of Analytical Methods [Published by: National Institute of Occupational Safety & Health, (NIOSH)].

c. The Occupational Environment - Its Evaluation and Control [Published by: American Industrial Hygiene Association, (AIHA)].

d. Industrial Ventilation "A Manual of Recommended Practice" latest edition [Published by: American Conference of Governmental Industrial Hygienists, (ACGIH)].

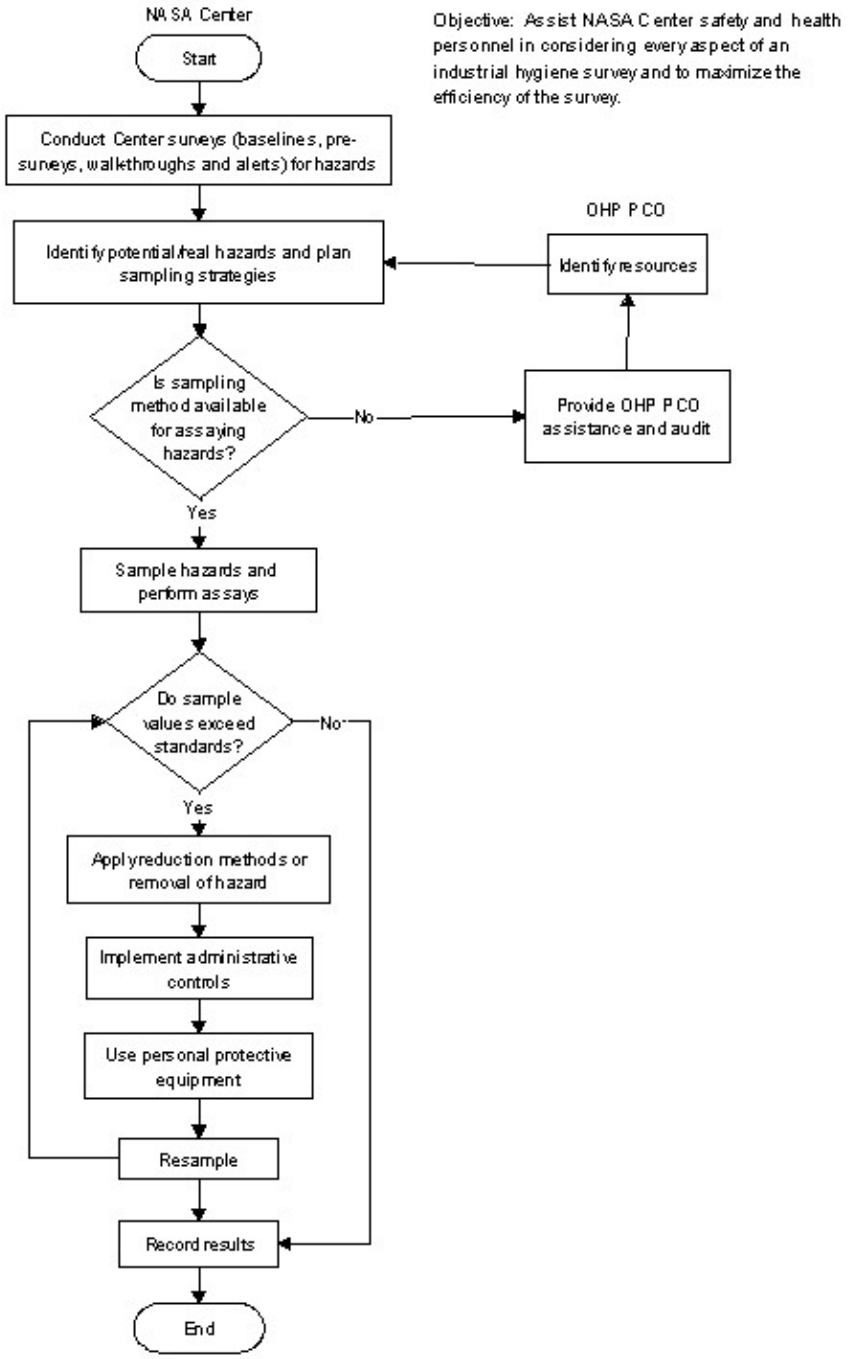
e. The Fundamentals of Industrial Hygiene (Published by: The National Safety Council)

f. Air Sampling Instruments, latest edition. (Published by: American Conference of Governmental Industrial Hygienists, ACGIH).

4.4.5 Flow Diagram

The flow diagram for this process is shown in Figure 4.4 at the end of this section.

4.4 Sampling and Analytical Methods and Equipment Calibration



4.5 Ergonomics

4.5.1 Introduction

a. Ergonomics is the science of fitting the job to the worker. When the interface between the job tasks and the worker performing those tasks is not properly considered and effectively designed, Musculoskeletal Disorders (MSD) can result. These disorders are injuries and disorders of the muscles, nerves, tendons, ligaments, joints, cartilage, and spinal discs. They do not include injuries resulting from slips, trips, falls, or similar accidents. Examples of MSD's include carpal tunnel syndrome, tendonitis, sciatica, herniated disc, and low back pain. Work-related MSD's are the most prevalent, most expensive, and most preventable workplace injuries in the

country. According to the Occupational Safety and Health Administration--

(1) Work-related MSDs account for more than one third of all occupational injuries and illnesses that are serious enough to result in days away from work.

(2) More than 600,000 employees suffer lost-workday MSD's each year.

(3) These injuries cost business $15 to $20 billion in workers' compensation costs each year. Total direct costs may run as high as $45 to $60 billion.

b. The loss of productivity, the cost of care, will all impact upon mission success. The goal of NASA's Environmental Health Program is to anticipate, recognize, evaluate and control environmental stressors arising from the workplace that may cause sickness, impaired health or well being, or significant discomfort and inefficiency among employees. For this reason, NASA requires usage of methods which provide best practices for employee protection. This approach allows the flexibility that Centers need to address the specific issues and operations that may be unique to each location. It ensures that Centers have a systematic, working process in place so they may take quick and effective action when MSDs occur.

4.5.2. Responsibilities

NASA Center Directors are responsible for providing a physically safe and healthy work environment for the Center employees and for implementing and operating environmental health programs. This includes establishing effective organizations to fulfill environmental health programmatic requirements using professionally qualified persons, allocating resources for the Environmental Health Program, and ensuring that Center managers, supervisors, and other personnel collaborate with Environmental Health personnel in meeting the requirements of the program and other applicable health policies, standards, and guidelines. The implementation of an effective multidisciplinary ergonomics program involving the interaction and cooperation of Medical, Safety, Environmental Health, Facilities, Engineering, and other organizational disciplines should be supported. Policies and practices should be aimed at the identification and prevention of MSDs.

4.5.3 Process Description

Each Center's ergonomics program must include at least the following elements:

a. Management Leadership and Employee Participation:

Management leadership of your ergonomics program must be demonstrated. Employees (and their designated representatives) must have ways to report "MSD signs" and "MSD symptoms;" get responses to reports; and be involved in developing, implementing and evaluating each element of the program. Policies or practices shall not discourage employees from participating in the program or from reporting MSDs signs or symptoms.

Hazard Information and Reporting:

b. A method for employees to report MSD signs and symptoms and to get prompt responses must be established. Employee reports of MSD signs and symptoms must be evaluated to determine whether a MSD has occurred. Information to employees that explains how to identify and report MSD signs and symptoms must be periodically provided.

c. Job Safety Analysis (JSA) and Process Controls:

Problem jobs must be analyzed to identify the ergonomic risk factors that result in MSD hazards. The MSD hazards must be eliminated, reduced to the extent feasible, or materially reduced using an incremental abatement process.

d. Training to employees must be provided so they know about MSD hazards and the ergonomics program as well as measures for eliminating or materially reducing the hazards. Training must be provided at no cost to employees, such that they are cognizant of the ergonomics program, MSD hazards, and methods for eliminating MSD hazards.

e. Ergonomics program must be reevaluated periodically and identified deficiencies corrected. Metrics that document the efficacy of the ergonomics program shall be maintained and used to improve the ergonomics program and to reduce MSD risks.

4.5.4 References

a. NPD 1800.2,NASA Occupational Health Program, dated January 16, 2001.

b. NPD 1820.1, NASA Environmenta , l H eal , th , Pro , gram, dated January 16, 2001.

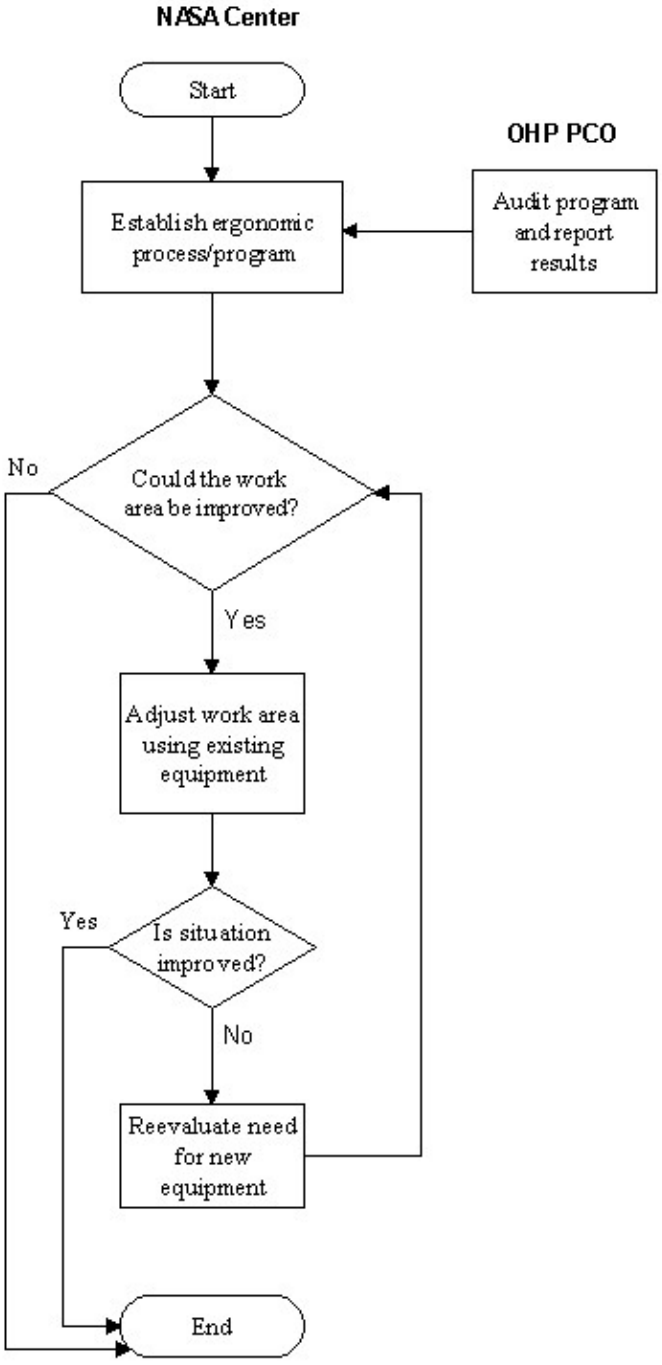
c. NPD 8710.2, NASA Safety and Health Program Policy, dated April 24, 2002

4.5.5 Flow Diagram

The flow diagram for this process is shown in Figure 4.5 at the end of this section.

4.5 Ergonomics

Objective: Establish and manage a program that anticipates, recognizes, evaluates and controls ergonomic hazards.



4.6 Radiological Health

4.6.1 Introduction

Radiological Health, also referred to as Health Physics, is included in the NASA Environmental Health Program. The intent of this program is to exercise centralized control over the procurement, use, storage, transportation, and disposition of ionizing and nonionizing radiation sources in order to limit the exposure of personnel, facilities, and the environment to levels of radiation that are As Low As Reasonably Achievable (ALARA).The goals of the program are

to protect the health of the public, astronauts and Pilots, NASA workforce and high value property and equipment so that NASA's mission may be effectively met; and to administer a program that is in compliance with all applicable Federal, state, and local regulations.

4.6.2 Responsibilities

a. All NASA Centers have the responsibility to ensure that they have a radiation protection program, if applicable, that complies with the above-stated intent and goals.

b. The Senior Environmental Health Officer serves as the Agency's Radiation Safety Officer and functions as the liaison between Centers and the OHP.

c. The Manager of the NASA OHP has functional management responsibility for the radiological health program which includes coordinating with the Safety and Risk Management Division, the Environmental Management Division, and others as necessary to ensure that applicable responsibilities are met.

4.6.3 Process Description

a. The Center Radiological Health program assures compliance with 10 CFR Part 20, 29 CFR 1910.96, 29 CFR 1910.97, and any other applicable regulation.

b. The NASA OHP performs the following functions with regard to all occupational aspects of the NASA Radiological Health program:

(1) Assesses regulatory compliance with 10 CFR Part 20, 29 CFR 1910.96, 29 CFR 1910.97, and other applicable regulations.

(2) Assists Centers with Nuclear Regulatory Commission licensing issues.

(3) Provides program oversight.

(4) Provides program assessment and auditing.

(5) Facilitates intercenter communication.

(6) Contributes program advocacy.

(7) Provides communication and coordination with the Office of Safety and Mission Assurance, Safety and Risk Management Division (Code QS), and the Environmental Management Division (Code JE)

(8) Serves as Agency representative on issues that require interaction and coordination with other Federal agencies and industry groups.

c. The NASA Centers maintain Radiological Health Programs (if applicable) that are in compliance with all appropriate Federal, State, and local regulations and that are consistent with the intent of the NASA policy. Each NASA Center communicates and coordinates with the NASA OHP in order that the above functions may be effectively performed.

d. Issues concerning the launching of radioactive materials fall under the purview of the Office of Safety and Mission Assurance. Refer to NPR 8715.3, NASA Safety Manual, chapter 5.

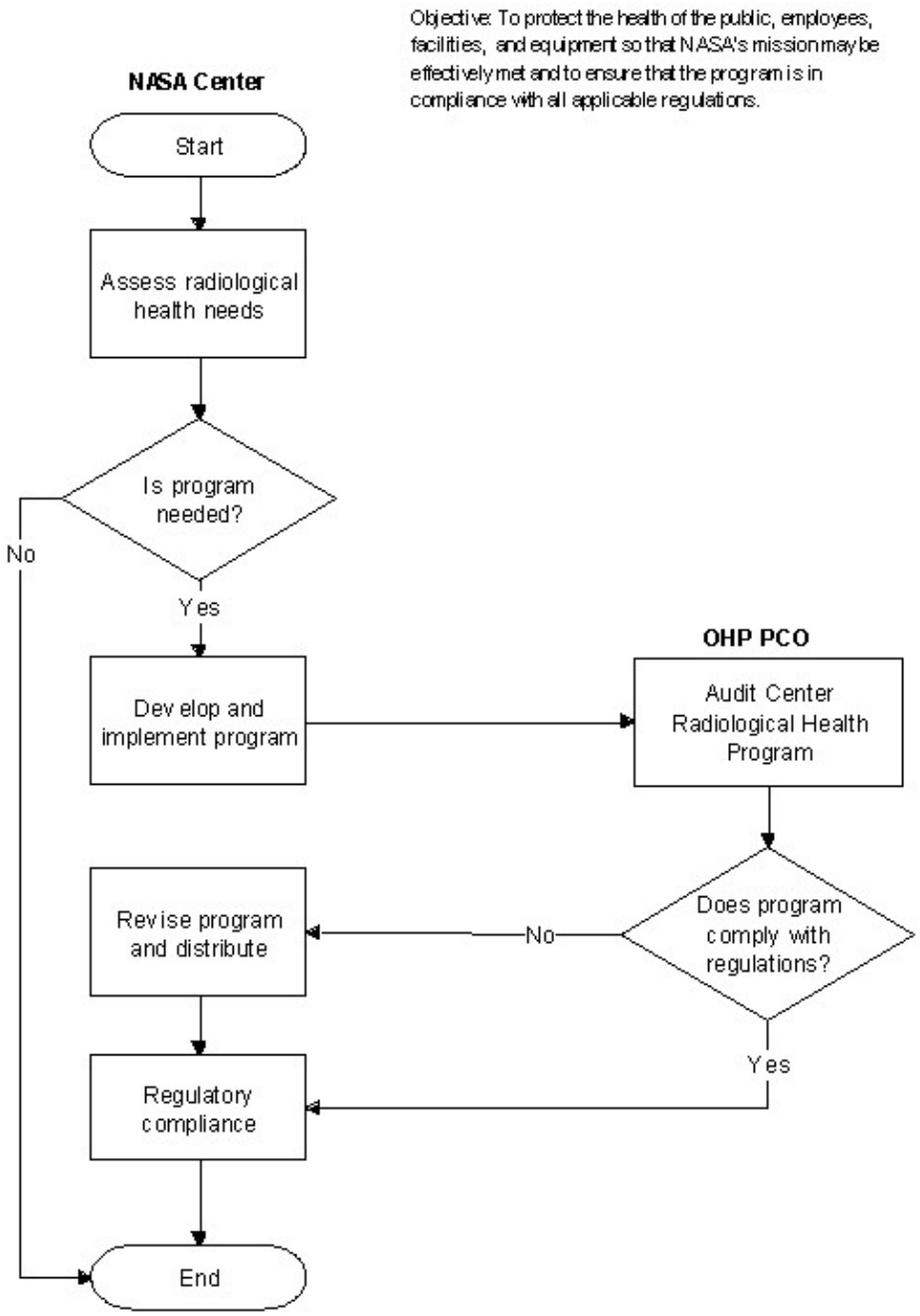
4.6.4 References

NPR 8715.3, NASA Safety Manual, dated January 24, 2000.

4.6.5 Flow Diagram

The flow diagram for this process is shown in Figure 4.6 at the end of this section.

4.6 Radiological Health



4.7 Environmental Sanitation

4.7.1 Introduction

In conjunction with the Agency's effort to provide its employees with a safe and healthy workplace, the NASA OHP oversees NASA Center environmental sanitation policies to ensure that OHP goals are achieved.

4.7.2 Responsibilities

a. NASA Centers must develop environmental sanitation programs that are preventive in nature. They reflect this approach by formally involving their safety and health offices in planning and review of all proposed projects, processes and procedures to eliminate or minimize, in advance, as many potential health hazards as possible. The Centers ensure that compliance with Agency policies and directives is maintained.

b. The OHP PCO assists Centers with developing environmental sanitation programs and performs audits of

existing programs.

4.7.3 Process Description

a. The Sanitation Program activities shall be centered around formal design/operational document reviews and both periodic and special surveys. The focus of these activities shall be, but are not limited to, the following:

(1) Facility sanitation.

(2) Disease vector surveillance.

(3) Potable water compliance monitoring.

(4) Food service sanitation compliance inspections.

(5) Monitoring of chemical toilets.

(6) Launch/landing support.

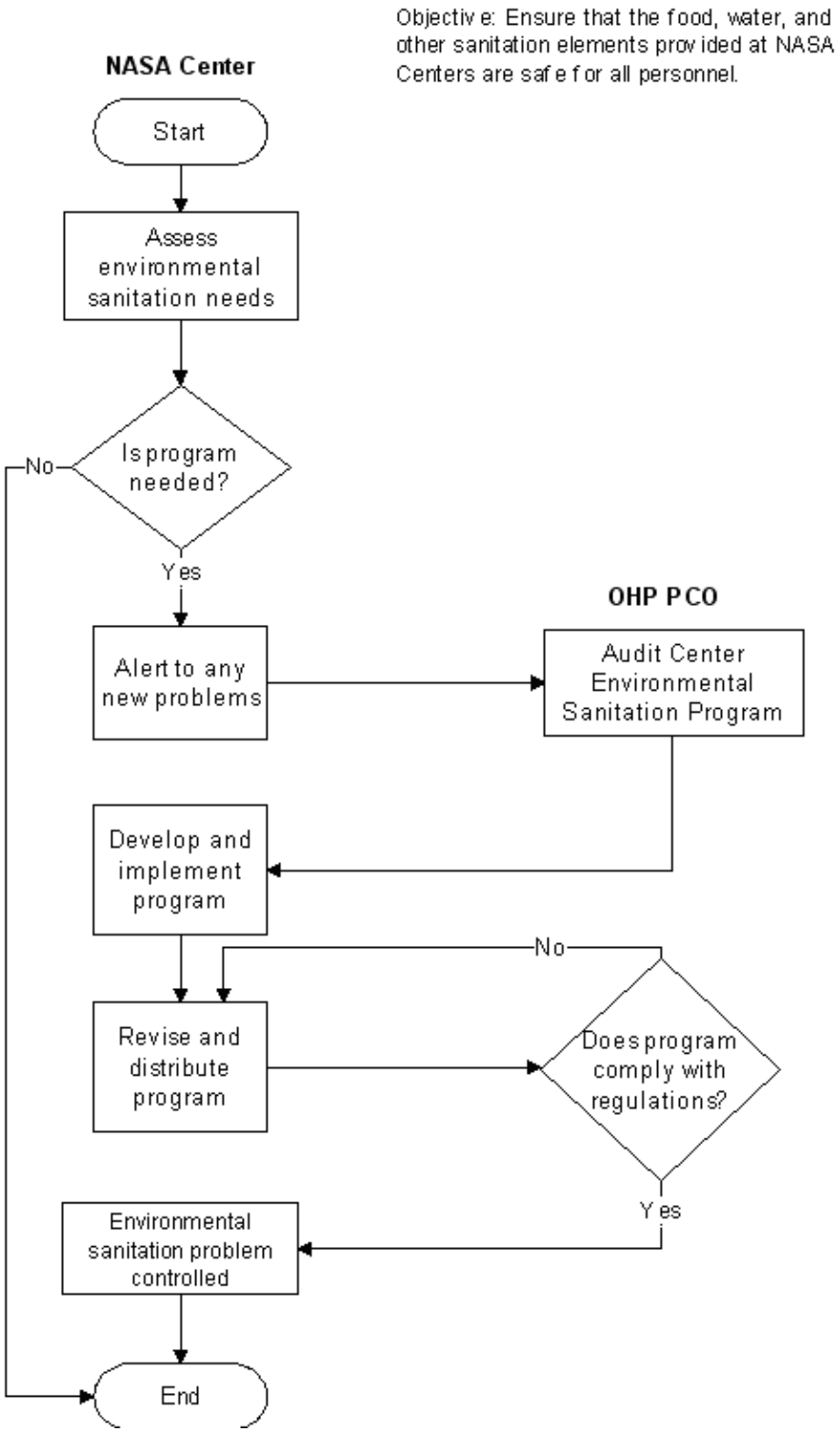
(7) Zoogenic problems.

b. NASA Centers shall maintain awareness of any developing local public health concern (e.g., West Nile fever from local birds, rodent-borne viruses.) and report any possible concerns to the OHP PCO.

Flow Diagram

The flow diagram for this process is shown in Figure 4.7 at the end of this section

4.7 Environmental Sanitation



4.8 Balancing Work-Rest Cycles

4.8.1 Introduction

a. People in occupations requiring prolonged or unusual time schedules are often subject to extraordinary work stress that has physiological and psychological consequences that can affect health and safety. Consideration of potentially detrimental impacts of unusual or varying worktimes must be given a high priority to prevent worker stress and undesirable outcomes.

b. Reserved.

4.8.2 Responsibilities

a. Center Directors and Senior Managers assure implementation to prevent work excesses and violations. They also provide appropriate means for arbitration of disputes and redress of offenses.

b. Center medical staff provide professional consultation to work managers and supervisors regarding requirements for standard and prolonged work schedules and work excesses.

c. Center EH Managers assure that potential exposures are appropriately evaluated and that OEL's are appropriately adjusted as necessary from the 8-hour time-weighted average to reflect actual conditions.

d. The OHP provides baseline guidance for work scheduling, assists Centers in their practical implementations, and conducts periodic audits of work records at Centers.

e. The NASA Headquarters OH Office issues relevant policy and directives and provides supporting advocacy and resources.

4.8.3 Process Description

a. Reserved.time

(1) Reserved.

(2) Reserved.

(3) Reserved.

(4) Reserved.

(5) Reserved.

(6) Reserved.

(7) Reserved.

(8) Reserved.

(9) Reserved.

(10) Reserved.

b. Definitions and Determinations

(1) Critical job categories are frequently identified in NASA operations. Not all tasks carry equal consequences for degraded performance or failure. Many Personal Reliability Positions (PRP) or Test Sensitive Positions (TSP) fall into the Critical job category. Criticality encompasses factors such as level of effort, urgency, safety, intrinsic value, success and failure, and consequences. For positions categorized as "critical," certain specific work-rest criteria will apply.

(2) Shift work is defined as work periods requiring well-defined, delimited duty for individuals, in sequential order to assure prolonged or continuous operations. By varying lengths of work periods and carefully scheduling shift changes, worker stress and fatigue can be minimized. A good outcome depends on balancing objective factors such as intensity and duration of effort, vigilance and decisions required, risks to the individual and the process, and also individual preferences. Most people find it easier to rotate work shifts with the earth's rotation-from day to evening to night-rather than counter to it.

(3) Circadian rhythms are inherent, periodic, autonomously running biological cycles normally entrained about the 24-hour, day-night cycle on Earth. Biochemical, endocrinological, immunological, physiological, and psychological processes exert influences causing a variety of system specific amplitudes of generally reproducible peaks and valleys, usually over a 24-hour cycle.

(4) Time zone changes-altering or shifting natural bodily rhythms requires considerable time to reach new equilibriums as evidenced in the well-known "jet lag" syndrome. Adaptation to an earlier (east to west) time zone is generally easier than to a later (west to east) time zone. This type of adaptation is similar in rotating work shifts as most people find it easier to shift from day to evening to night periods rather than the opposite direction. Consideration should be given to allowing for adaptation times to avoid critical decisions in a chronobiologically impaired state. Benefits and preferences for scheduled shorter or longer time periods at a given shift remain controversial. In the aggregate, however, circadian rhythms materially affect physical capability, mental alertness and decisionmaking, and overall well being that can predispose to illness or injury-and hence, adversely impact work capacity, quality of performance, and safety. These biological rhythms cannot be ignored.

(5) The calendar year, the week, and the calendar day (which changes at midnight) shall be used for worktime evaluation and maintenance of records. Accurate time records are mandatory in all work considerations.

(6) There must be a balance of workload and workforce capability and a balance between work and restorative times-such as sleep or rest, family or nonwork social interactions. On the other hand, a distinction between customary and expected pressures and stresses of meeting deadlines, physical effort, and the rigors of interaction with people and the environment must be clearly made versus those stresses derived from pushing the envelope of psychophysiological endurance and limits.

c. Worktimes

The following is based upon worktimes used at KSC and Langley Research Center (LaRC), and Commission recommendations for Nuclear Regulatory Commission policy on shift scheduling and overtime at nuclear power plants.

(1) For "critical" positions:

(i) Level Green-Employee has choice of 5 days of 8 hours per day or 2 consecutive days of 12 hours per day, with a maximum of 60 hrs. per week.

(ii) Level Yellow-Where specific job circumstances - "problems during operations"- exist, one should not work more than 16 hours in a day or more than 2 16-hour days in a month with 192 hours maximum.

(iii) Level Red-Immediate supervisor approval is needed if above work durations are exceeded beyond 16 hours per day in a week or twice per month, or beyond other green level maximums, to avoid possible adverse health and safety effects. A minimum of 10 hours between shifts is recommended; consideration should be given to a half shift the next day to avoid rotating into another shift cycle. The employee, even with supervisory approval, should not exceed 2260 hours annually. Working up to 24 hours per day or more than 72 hours per week will require Chief Safety Officer and/or Center Director approval and notification of project and/or line management because of increased safety risk and short-term health effects, and increased risk of impact upon the NASA mission. Since the risks of fatigue, errors, and health effects increase with prolonged work hours, 2300 hours in a year should not be exceeded without Chief Safety Officer and/or Center Director approval; 2500 hours a year should not be exceeded.

(2) The ranges of general work positions can be considered as the following, which take into account increasing fatigue with increasing work durations:

(i) Level Green-Employee has choice of 5 days of 8 hours per day or 2 consecutive days of 12 hours per day, with a maximum of 60 hours per week.

(ii) Level Yellow/Red- Where specific job circumstances - "problem during operation" - exist, one should not work more than 16 hours in a day or more than two 16 hour days in a month with 192 hours maximum and 2260 hours a year. Immediate supervisor approval is needed if above workday durations are exceeded beyond 12 hours per day. Work beyond 16 hours a day would require a Centerwide Declared Emergency (CDE) or Program Declared Emergency (PDE) with Chief Safety Officer and/or Center Director approval.

Exceptions or extensions to standard, or "optimal" lengths of work periods may be required or desirable in particular circumstances. The traditional "standard" 5-day, 8-hour shift is becoming frequently replaced with three consecutive, 12-hour shifts - compensated to the worker by more time/days off. Beyond this, further extensions of work intervals may be dictated by an operation/task or preferred by all personnel involved in a given process. Duration and scheduling of off-time intervals must be factored in, and may limit maxima, in any extension of worktime. Principles for assessing the three levels of work scheduling/duration delimited above are given below:

(iii) Level Green: The standard, routine, optimal schedule (e.g., 5 8-hour workdays, or shifts, per week), may be sustained by normal, healthy adult workers indefinitely. When the 8-hour period is shifted within the 24-hour day-night cycle, compensatory time must be allowed for circadian rhythms to adapt. Alternatives may include the popular 12-hour shift schedule for not more than three consecutive shifts, and compensatory time for rotation of shifts also applies.

(iv) Level Yellow/Red: Work scheduled beyond Level Green will include occasional, isolated shifts for up to 18 hours with increased restorative time allowed, especially when high vigilance or important decisions are involved. This situation may also be encountered with long, transmeridional plane travel.

3. Work of such urgent nature or situational circumstances as to require performance essentially at endurance capacity sometimes is required. This may be invoked for life-threatening emergencies, natural disasters, mass casualty accidents, or war. There will always be, however, the red line, an absolute limit to extensions and exceptions for work periods, regardless of the imperative. Such situations demand careful evaluation of the total scenario and prudent scheduling of work periods when pressing workers to and beyond biological limits. Such limits may not be exceeded without consequences to safety and well being of workers and to the integrity of the work process.

4. Overtime may be required because of a problem during operation or because of an extended work process. In either case, overtime shall not exceed the stated guidelines. Unusual circumstances may arise that require deviation from the guidelines. Such deviations shall be authorized by the first-level director. (This authorization must be

documented and made available for NASA management inspection.) An extended work process shall not be considered unusual circumstances.

5. NASA Centers may wish to define "very unusual circumstances" using the categories found in the emergency plans at individual Centers and for specific work processes.

6. Further recommendations concerning routine 12-hour/day shift schedules are as follows:

(i) The basic 12-hour/day schedule should be "2-on, 2-off," "3-on, 3 off," or "4-on, 4-off."

(ii) Each Center should have the capability to cover unexpected absences satisfactorily without having individuals work more than 12 hours per day.

(iii) The general safety record of the Center should be satisfactory, based on general criteria such as those used in NASA's Langley Research Center.

d. Variances

Management and unions work together to approve variances to stated guidelines, though advanced written approval is required. In unusual circumstances, a NASA review may be indicated. Managers, supervisors, and other specialists (e.g., Contracting Officer/Contract Technical Monitor, medical representative, Employee Assistance Program counselor, union representative) may participate in such reviews. The objective is to guard against arbitrary interpretation and possible excesses leading to maximum worktime violations. Any violations to maximal worktime requirements shall be reported immediately to the director of the primary organization. Resolution shall be sought at the lowest management level. Final arbitration lies with the Medical Policy Board.

e. Recommendations to Minimize Worker Stress and Fatigue Related to Time Factors

(1) Define the "standard" work period for all operations and tasks regarding multiple and rotating shifts if required, as well as sleep-rest, breaks, restoration intervals.

(2) Clarify responsibilities, work expectations, and desired outcomes for any process or decision.

(3) Minimize negative consequences of shifting worktimes by the following:

(a) Having an employee select preferred shifts consistent with mission needs.

(b) Considering individual circadian rhythms to insure adequate work and sleep-rest cycles.

(c) Allowing adequate time for adaptation and recovery from old to new shift or time zone.

(d) Knowing the "criticality" of the work to evaluate risk of physiological and psychological consequences of chronobiological stress.

(4) Define "critical job categories" and assure that employees assigned to these categories understand the full implication with respect to work schedule, load, and irregularities. Educate employees about the work and potential impact including effects on total life style, as workers cannot dissociate worktime from time spent elsewhere.

(5) Define "extended" work periods for job categories.

(a) Allow "exceptions" to standard work requirements by strict criteria:

(b) Need, urgency, benefit.

(c) Risks.

(d) Prior anticipation noted in position description and by positive work relationships between employee and supervisor.

(6) Maintain accurate records of work schedules.

(7) Define "violation" of allowable maximum worktime with care to differentiate it from extended work or exceptions, to assure no misunderstandings. Make consequences of violations unmistakable.

(8) Consider salutary and synergistic actions by both organization and individual.

(9) Provide an impartial council to hear and resolve disagreements.

f. Adjustment and Application of Occupational Exposure Limits to Unusual or Extended Work Shifts

(1) The American Conference of Governmental Industrial Hygienists (ACGIH) states in the introduction of its publication, Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, that Threshold Limit Values (TLV) refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be exposed day after day without adverse health effects. TLV's

expressed as time-weighted averages are based on conventional 8-hour workdays and 40-hour workweeks. These exposure limit values assume a relationship between contaminant accumulation in the body while exposed at work and contaminant elimination from the body while away from work (presuming no additional exposure). Work shifts which extend beyond conventional 8-hour per day/40-hour per week schedules upset the accumulation/elimination balance by providing greater periods of potential exposure and shorter periods of no exposure. The industrial hygienist uses professional judgment to ensure equal protection to workers on unusual shifts.

(2) Several models exist which can provide guidance for the adjustment and application of OEL's to unusual shifts. The most commonly referred to being the Brief and Scala model. This model and others are described at length in Patty's Industrial Hygiene and Toxicology.

4.8.4 References

a. Rosa, Roger R. and Michael J. Colligan, Shift Work: Health and Performance Effects, Chapter 100, pp 1173-1177. In William N. Rom (Ed.), Environmental and Occupational Medicine (2nd Ed.), Little, Brown and Company, Boston, 1992.

b. Scott, Allene Jane (Ed.), Shiftwork-Occupational Medicine State of the Art Review, Hanley and Belfus, Inc., Philadelphia, 1990.

c. Seward, James P., Occupational Stress, Chapter 34, pp 585-600. In J. LaDou (Ed.) Occupational and Environmental Medicine, Appleton & Lange, Stamford, 1997.

d. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, 2000.

e. Paustenbach, D.J.: Occupational Exposure Limits, Pharmacokinetics, and Unusual Work Schedules. Patty's Industrial Hygiene and Toxicology, 3rd Ed. Volume IIIA, The Work Environment, Chap. 7, pp. 222-348. R.L. Harris, L.J. Cralley and L.V. Cralley, Eds. John Wiley and Sons, Inc. New York (1994).

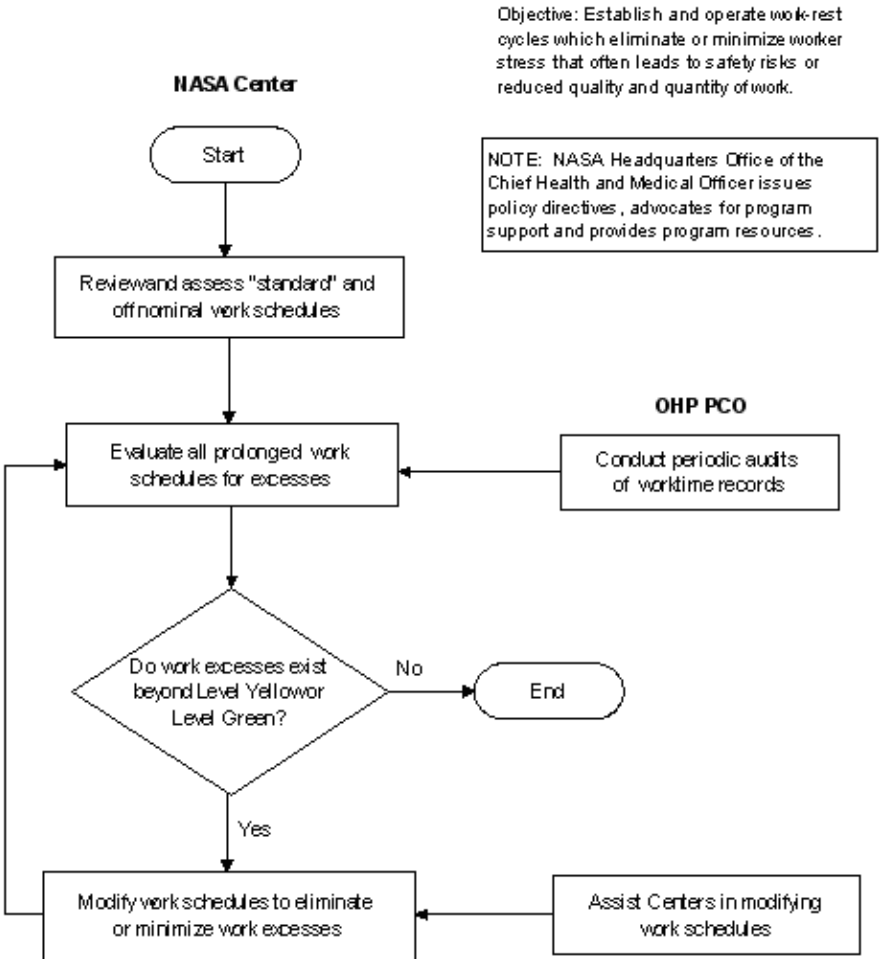
f. U.S. Department of Transportation, Publication DOT-MC-99-129 An Annotated Literature Review Relating to Proposed Revisions to the Hours-of Service Regulation for Commercial Motor Vehicle Drivers, November, 1999.

g. Nuclear Regulatory Commission, IE Circular no. 80-82, Nuclear power Plant Staff Work Hours, February 1, 1980.

4.8.5 Flow Diagram

The flow diagram for this process is shown in Figure 4.8 at the end of this section.

4.8 Balancing Work-Rest Cycles



4.9 Hearing Conservation

4.9.1 Introduction

a. This section establishes minimum requirements for an Agency-wide Hearing Conservation Policy. Centers, Component Facilities, Headquarters, and JPL are hereafter referred to as "Centers." This section outlines NASA's requirements for preventing noise-induced hearing loss where employees are occupationally exposed to hazardous noise in all occupational settings, including all ground-based operations, all aircraft operations, and all aircraft pilots and crew members. This section does not apply to space flight operations.

b. The requirements of the latest revision of 29 CFR 1910.95, Occupational Noise Exposure Hearing Conservation Amendment Final Rule and appendices, and the requirements of the latest revision of 29 CFR 1904.10, Occupational Injury and Illness Recordkeeping and Reporting Requirements, for cases involving occupational hearing loss are incorporated herein by reference and shall be followed unless otherwise specified in this section.

c. Where conflicts exist between other NASA health and safety requirements, 29 CFR 1910.95, Occupational Noise Exposure Hearing Conservation Amendment Final Rule and appendices, 29 CFR Part 1904.10, Occupational Injury and Illness Recordkeeping and Reporting Requirements, and this section, the most protective requirements shall apply.

d. Centers shall take steps to inform and protect all personnel from potential risks to their hearing that may be encountered in, or derived from, the workplace.

e. Centers shall have a written Hearing Conservation Program (HCP) which, at a minimum, addresses the requirements and provisions of this section and requires their contractors to have HCPs in accordance with the NASA FAR Supplement 1852.223-70, Safety and Health.

f. Occupational health personnel, trained in sound analysis, noise exposure assessment, hearing protection, audiometric testing, and noise abatement strategies, shall review their Center's HCP, including the hazardous noise training program, for adequacy at least every 3 years and more frequently if program requirements change.

g. Centers shall implement a "Buy Quiet and Quiet by Design" program and a system to effectively prioritize noise surveys and noise remediation efforts as part of their HCP and in accordance with the provisions of this section.

h. Communication and coordination between and among Center managers, supervisors, employees, engineers, environmental health personnel, and the Medical Director shall be implemented to properly identify, evaluate, and control hazardous noise and to prevent hearing loss caused by exposure to hazardous noise.

i. Center Directors and affected Program and Project Managers shall be notified of all operations and equipment not conforming to this section or the Center's HCP.

4.9.2 Responsibilities

a. The Designated Agency Safety and Health Official (DASHO) shall provide resources for the development and review of the Agency's Hearing Conservation Policy and for implementation of the Office of the Chief Health and Medical Officer (OCHMO) responsibilities contained therein.

b. The Director, Agency Occupational Health Program, shall provide direction for, and approval of, the Agency's Hearing Conservation Policy.

c. The Senior Environmental Health Officer shall:

(1) Make recommendations and provide advice concerning hearing conservation to the Director, Agency Occupational Health Program, and the DASHO, when requested.

(2) Biannually r eview the adequacy of HCPs at each Center.

d. The Chief Engineer and the Assistant Administrator for Infrastructure and Administration shall ensure that ?Buy Quiet and Quiet by Design? provisions are integral to the site selection and design of new or modified facilities and equipment.

e. The Assistant Administrator for Procurement s hall ensure that "Buy Quiet and Quiet by Design" provisions are included in all contracts and in the purchase of new equipment, as appropriate.

f. Center Directors, Component Facility Directors, and the Assistant Administrator for Infrastructure and Administration shall ensure the following:

(1) Adequate resources are provided to implement Center HCPs.

(2) Approved HCPs are implemented at their Centers.

g. Facility Managers, design engineers , occupational health personnel, and employers of affected employees shall implement the provisions of their Center's HCP.

h. Contracting Officers shall ensure that Center contract requirements include provisions for written HCPs in accordance with the NASA FAR Supplement 1852.223-70, Safety and Health.

4.9.3 Process Description

a. Definitions in 29 CFR 19 , 10.95, Appendix I, shall be used in this document unless otherwise defined below.

(1) Ability and Risk Evaluations - Evaluations performed for the purpose of determining a worker's ability to perform specific job tasks (ability) and the likelihood of harm, either to the worker or others (risk), in relation to anticipated workplace exposures and job demands. Also includes the processes used to evaluate the ability of individuals to safely perform essential duties, if placed in a noisy work environment, and not pose a health or safety risk to themselves or others.

(2) Action Level - An 8-hour time-weighted average of 82 decibels measured on the A-scale, slow response, or equivalently, a dose of 50 percent. Employee exposure at or above the action level triggers enrollment into a hearing conservation program.

(3) Administrative Control - Any procedure that limits noise exposure by restricting access to noise areas or by control of exposure times, distance, and/or work practices.

(4) Audiogram - A chart, graph, or table resulting from an audiometric test showing an individual's hearing threshold levels as a function of frequency.

(5) Audiologist - A professional, specializing in the study and rehabilitation of hearing, who is certified by the American Speech-Language-Hearing Association or licensed by a state board of examiners.

(6) Audiometer - An electronic instrument used for measuring hearing threshold levels that conforms to the requirements and specification of the current American National Standard Institute (ANSI) S3.6, Specification for Audiometers standard.

(7) Baseline Audiogram - The audiogram against which future audiograms are compared.

(8) "Buy Quiet and Quiet by Design" Program - A program that endeavors to achieve long-term reduction of employee noise exposures through purchase and design of equipment with the intention of achieving realistic and achievable noise criteria, which are considered before procurement or design, using criteria based on operational conditions as well as the noise outputs of equipment. The "Buy Quiet and Quiet by Design" approach requires designers and engineers to consider noise emission when purchasing and designing equipment that is expected to generate noise emission levels of concern for hearing conservation (80 dBA and higher).

(9) Calibration - A check of proper functioning and stability of an audiometer, sound level meter or octave band analyzer, noise dosimeter, or audiometric test room by various means. Where methods or requirements vary, the methodology or specification that results in the most accurate data collection shall apply.

(10) Criterion Sound Level - A sound level of 85 dBA TWA, which is NASA's maximum occupational exposure level.

(11) Decibel (dB) - Unit of measure of sound level.

(12) Decibel A-weighted (dBA) - A sound level reading in decibels made on the A-weighted network of a Sound Level Meter (SLM) at slow response.

(13) Decibels, Peak (dBP) - The highest instantaneous sound level measured. Commonly used to measure impulsive or impact noise. This quantity cannot be measured on the slow response A-weighted scale.

(14) De-rating - The process reassigning the manufacturers' values of hearing protectors to more realistic, real-world performance values.

(15) Dose - The amount of actual noise exposure relative to the amount of allowable noise exposure and for which 100 percent and above represents noise exposures that are hazardous.

(16) Employer - NASA organizations and their associated contractors, to the extent specified in their respective contracts, and other Government agencies, their contractors, and tenants whose primary work is performed at a NASA Center.

(17) Engineering Control - Any mechanical device or physical barrier that reduces the sound level at the source of noise generation or along the path of propagation of the noise to the potentially exposed individual. This does not include personal protective equipment such as earmuffs or plugs or administrative controls.

(18) Exchange Rate - The increase or decrease in decibels corresponding to twice (or half) the noise dose. When using a 3 dB exchange rate, a dose corresponding to an exposure of 85 dBA TWA represents twice the dose associated with an 82 dBA TWA exposure.

(19) Hazardous Noise Area - Any work area where the environmental noise level is at or above 85 dBA, or where the environmental impulse noise level is at or above 140 dB peak C or linear, regardless of duration of exposure or number of impulses.

(21) Hertz (Hz) - Unit of measurement of frequency, numerically equal to cycles per second.

(22) Impulsive or Impact Noise - Variations in noise levels that involve peaks of intensity that occur at intervals of greater than 1 second. If the noise peaks occur at intervals of 1 second or less, the noise is considered continuous.

(23) Medical Pathology - A disorder or disease.

(24) Noise - Sound level or sound emission.

(25) Noise Dose - A measure of cumulative noise exposure over a stated time period, which takes into account both the intensity of sound and the duration of exposure.

(26) Noise Dosimeter - An instrument that integrates a function of sound pressure over a period of time in such a manner that it directly indicates a noise dose.

(27) Noise Reduction Rating (NRR) - A noise reduction value, in decibels, averaged across the frequencies from 125 Hz to 8 kHz, computed from laboratory tests of the attenuation of hearing protectors measured under ideal conditions. The NRR, per a 1979-EPA regulation, is required to appear on all devices worn on the head or ear that are sold for purposes of personal noise reduction. See "Derating."

(28) Noise Survey - A periodic or event-driven investigation of a hazardous noise, Standard Threshold Shift (STS), or other driving condition for the purposes of determining the noise levels, frequencies, and other sound characteristics as they relate to employee exposure.

(29) Occupational Hearing Conservationist (OHC) - A lso known as an industrial audiometric technician. A person who, under the supervision of an audiologist or physician, conducts the practice of hearing conservation, including pure-tone air-conduction hearing testing and other associated duties.

(30) Otolaryngologist - A physician specializing in diagnosis and treatment of disorders of the ear, nose, and throat.

(31) Representative Exposure - Measurements of an employee's noise dose or 8-hour time-weighted average sound level that is representative of the exposure of other employees exposed to the same noise hazard.

(32) Revised Baseline - The most recent audiogram that has established a persistent STS upon retest or a significant improvement. Baseline revisions shall be used as the basis of comparison for future audiograms. Since ears are considered separately when making baseline revisions, it is possible for someone to have baseline audiograms from different years, as well.

(33) Significant Improvement - A significant improvement is shown if the average of thresholds at 2000, 3000, and 4000 Hz for either ear shows an improvement of 5 dB or more from the baseline audiogram.

(34) Sound Pressure Level (SPL) - 20 times the common logarithm of the ratio of the square of the measured A-weighted sound pressure to the square of the standard reference pressure of 20 micropascals.

(35) Sound Level Meter - An instrument for the measurement of sound level.

(36) Standard Threshold Shift (STS) - A decline in hearing threshold of 10 dB or more from baseline at 2000, 3000, and 4000 Hz (average) in either ear.

(37) Time-Weighted Average (TWA) Sound Level - That sound level which, if constant over an 8-hour exposure, would result in the same noise dose as is measured.

(38) Work Role Position - Any job or position at a Center that does not change appreciably when a contract is awarded to a new contractor and the same employee of the former employer occupies the position.

b. Written HCP:

(1) All Centers shall develop and maintain a written HCP to implement the requirements of this section.

(2) At a minimum, the HCPs shall include provisions for:

(i) Specifying the individual responsibilities of Facilities Managers, Design Engineers , Occupational Health Personnel , Supervisors, and Employees.

(ii) Assuring that noisy areas are surveyed to determine if they are hazardous noise areas.

(iii) Affirming the criterion sound level and exchange rate.

(iv) Evaluating and maintaining the HCP's effectiveness.

(v) Implementing "Buy Quiet and Quiet by Design" Programs.

(vi) Exposure monitoring.

(vii) Medical surveillance (audiometric monitoring).

(viii) Notification and coordination between employees, management and occupational health personnel of noise exposure and dosimetry monitoring and survey results, operational and design plan review results, the addition of new equipment or new operations, and any work-related STS.

(ix) Audiometric testing, review, and medical follow-up.

(x) Selection, use, cleaning, and inspection of hearing protectors.

(xi) Training and certification for employees and supervisors exposed at or above the action level.

(xii) Certification of occupational hearing conservationists.

(xiii) Recordkeeping and access to information.

(xiv) Policy documentation.

(xv) Noise control requirements and strategies.

(xvi) Effective implementation of engineering, operational, and administrative controls.

(xvii) Appropriate corrective actions for employees who violate requirements of this section, the Center's HCP requirements, or 29 CFR 1910.95, "Occupational Noise Exposure Hearing Conservation Amendment Final Rule," and appendices.

c. HCP Participation:

Whenever an employee is occupationally exposed to noise equal to or exceeding the action level (an 8-hour time-weighted average sound level [TWA] of 82 decibels measured on the A scale [slow response] or, equivalently, a dose of 50 percent for

30 days or more per year), the Center or Facility shall administer a continuing, effective hearing conservation program in conformance with the requirements of this section and the affected employees included in the program. Exposures shall be computed without regard to any attenuation provided by the use of personal protective equipment.

d. Noise Exposure Limits:

(1) NASA's allowable noise exposure limit is the equivalent to an 85 dBA, 8-hour TWA exposure using a 3 dB exchange rate. Table 1 contains noise exposure levels and durations that are equivalent to this limit as calculated by the following formula where *L* stands for exposure level and *T* for duration:

$$T\ (\text{min}) = 480/2^{(L-85)/3}$$

Exposures exceeding the equivalent exposures in Table 1 shall be controlled, reduced, or eliminated through a hierarchical combination of engineering controls, administrative controls, and hearing protection devices.

Table 1

Noise Exposure Limits

Exposure level (dBA)	Hours	Minutes	Seconds
80	25	24	0
81	20	10	0
82	16	0	0
83	12	42	0
84	10	5	0
85	8	0	0
86	6	21	0
87	5	2	0
88	4	0	0
89	3	10	0
90	2	31	0
91	2	0	0
92	1	35	0
93	1	16	0
94	1	0	0
95	0	47	37
96	0	37	48
97	0	30	0
98	0	23	49
99	0	18	59
100	0	15	0

(2) Noise dose shall include all impact/impulse noise measured up to and including 140 dB peak.

(3) The action level is 82 dBA 8 hour TWA.

(4) All personnel who enter designated areas or who perform tasks where exposure to noise is greater than or equal to 82 dBA regardless of the duration of exposure shall be provided with personal hearing protection. All personnel who enter designated hazardous noise areas or who perform tasks where exposure to noise is greater than or equal to 85 dBA or 140 dB peak, regardless of the duration of exposure or number of impulses, shall be provided with and shall be required to wear personal hearing protection.

e. ?Buy Quiet and Quiet by Design? Programs shall:

(i) Meet realistic and achievable baseline noise criteria and optimize noise emission criteria based on individual and specific operational and site conditions.

(ii) Encompass design and development, or selection and purchase, of a broad variety of fixed and portable equipment purchased for use by Centers, including equipment purchased by contractors, to minimize noise-exposure hazards to personnel.

(iii) Encompass equipment expected to produce noise which is approaching hearing conservation levels of 80 dBA and higher under a variety of site and operational considerations.

(iv) Identify noise emission and control requirements for equipment procurement specifications and design.

(v) Contain provisions for ?Buy Quiet and Quiet by Design? program support, promotion, training, and management sponsorship.

(vi) Be individualized to meet the Center's specific needs, configuration, and other relevant factors.

(vii) Not apply to specialized research project items or flight hardware, which may be expected to produce large amounts of noise.

f. Engineering Controls:

(1) Engineering controls shall be the first and primary means of controlling hazardous noise. The feasibility and cost of engineering controls may be considered when making decisions about these controls.

(2) Engineered noise controls should attempt to reduce noise emissions (measured at operator position or equivalent) to below 85 dBA.

(3) Facility plans shall be reviewed to assess the adequacy of precautions that are planned and/or undertaken to control noise exposures.

(4) Engineering projects, drawings, and operational plans, including noise control measures, shall be coordinated with affected management organizations and occupational health personnel in the early stages of the design and/or planning process and prior to contract award and/or authority to proceed.

(5) Organizations responsible for introducing changes to facilities, operations, or procedures shall notify occupational health personnel of:

(i) Any changes in operations or equipment that increase noise levels.

(ii) Any new, uncontrolled, or previously unidentified areas, operations, or equipment that may produce hazardous noise or may not comply with the requirements of this section.

g. Administrative Controls:

(1) If e ngineering controls fail to reduce sound levels within the requirements specified in this section, administrative controls shall be utilized. Examples of administrative controls include access restrictions and time limitations in the hazardous noise area.

(2) The distance between the employee and the hazardous noise source shall be maximized to the extent practical.

(3) Hazardous Noise Area Identification shall be implemented as follows:

(i) Areas determined to be hazardous noise areas shall be identified by posting with signs that conform to 29 CFR 1910.145 - Specifications for accident prevention signs and tags requirements.

(ii) Signs shall clearly indicate the presence of hazardous noise and state the requirement to wear hearing protection. The signs shall be posted at the entrance(s) to or the periphery of hazardous noise area(s).

(iii) Decals or placards with similar statements shall be affixed to power tools and machines that produce hazardous noise levels, and cautions signs shall be posted in areas where hazardous noise-producing tools and machines are used.

h. Personal Hearing Protection Devices (HPDs):

(1) If both e ngineering and administrative controls fail to reduce sound levels to 85 dBA TWA or below, p ersonal hearing protection shall be used to bring exposure levels to acceptable levels .

(2) HPDs shall be made available for use in sound levels at or above 82 dBA. HPDs shall be worn by employees when they are exposed to noise levels in excess of 85 dBA, independent of duration of exposure.

(3) Earplugs shall be for the exclusive use of each employee and shall not be traded or shared.

(4) HPDs shall attenuate employee noise exposure to an 8-hour TWA of 85 dBA or less. For those with STS, HPDs

shall attenuate exposure to an 8-hour TWA of the 82 dBA or less.

(5) The following derating criteria shall apply for all types of HPDs, where ?NRR? is the manufacturer's Noise Reduction Rating:

Required NRR = [(L A ? 85) x 2] + 7, where L A is the measured ambient sound level to which the employee is exposed.

(6) The adequacy of HPD attenuation shall be reevaluated whenever employee noise exposures increase.

(7) Special hearing-protective equipment, such as sound-suppression or noise-cancellation communication headsets, shall be regularly inspected if they are used in hazardous noise areas.

(8) Sound-suppression and noise-cancellation headsets that have been damaged, altered, or modified in any way that affect the attenuation characteristics shall not be used.

(9) Where sound-suppression and noise-cancellation headsets are not permanently issued to individuals, such equipment shall be cleaned and sanitized before re-issuance.

i. Exposure Monitoring:

(1) Noisy areas shall be surveyed to determine if they are hazardous noise areas.

(2) Measurement of potentially hazardous sound levels shall be conducted when any information, observation, or calculation indicates that an employee may be exposed to noise at or above the action level. This includes, but is not limited to, times where there is a need to document representative noise exposures, where employees complain of excessive noise, or where it is difficult to understand a normal conversation when the speaker and listener face each other at a distance of 3 feet.

(3) In determining TWA exposures, all continuous, intermittent, and impulsive sound levels, from 80 dBA to 140 dBA, shall be integrated into the noise measurements.

(4) Octave band analysis shall be conducted, when required, to establish the characteristics of the noise source and to help determine appropriate abatement techniques.

(5) When a noise survey is performed, it shall determine the presence of compounding hearing-related circumstances present in the environment (e.g., certain solvents, heavy metals, carbon monoxide, heat, and vibration) to ensure proper mitigation.

(6) Noise surveys shall also be conducted whenever any changes to facilities, equipment, work practices, procedures, or noise-control measures alter potential noise-exposures. A review of hazardous noise sources and controls, employee exposures, and work practices and procedures shall be conducted for changed conditions whenever an employee experiences an STS.

(7) When a noise survey shows that any employee or group of employees may be exposed to noise at or above 82 dBA 8-hr TWA, noise dosimetry monitoring will be conducted to determine the noise dose of the exposed employee and the representative exposure of similarly exposed employees and to determine appropriate noise abatement techniques.

(8) All noise surveys and personal noise dosimetry monitoring conducted shall be consistent with 29 CFR 1910.95 requirements, unless otherwise specified in this section.

(9) Operational plans shall be reviewed to assess the adequacy of precautions that are planned and/or implemented to control noise exposures.

(10) Baseline surveys of each new or changed operation, job, or procedure, having the potential of creating hazardous noise, shall be conducted.

(11) New equipment, operations, jobs, or procedures, with the potential for creating hazardous noise, shall be evaluated with regard to noise emissions prior to operational start-up.

(12) Employees and/or their representatives shall be provided an opportunity to observe noise dosimetry and area monitoring activities.

(13) Affected employees shall be notified in writing of the results of noise dosimetry monitoring.

(14) Employers of affected employees and the appropriate occupational health program managers shall be notified when noise measurement data indicate that noise exposures equal or exceed the limitations of Table 1 and the action level. Written reports of the hazardous noise surveys that identify all survey observations, findings, and conclusions shall also be provided to affected employees.

(15) Randomly selected hazardous noise areas shall be surveyed and documented each year to assure program effectiveness.

j. Sound-Measuring Equipment:

(1) An instrument used to measure workers' noise exposures shall be field-calibrated prior to each use and shall be checked periodically, at least annually, by its manufacturer, a representative of its manufacturer, or an approved laboratory.

(2) Sound-level meters used to measure workers' noise exposures shall be set at ?slow? response and A-weighting.

k. Audiometric Test Equipment:

(1) Audiometric test equipment shall be calibrated to meet the requirements specified in the latest revision of ANSI S3.6, Specification for Audiometers.

(2) Ambient noise levels in audiometric test rooms and booths shall meet the specifications in the latest version of ANSI S3.1, Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms.

l. Medical Surveillance:

(1) Audiometric Examination:

(i) Employees enrolled in an HCP shall receive medical surveillance as part of the HCP.

(ii) Employees receiving medical surveillance shall undergo a baseline audiometric examination before beginning work assignments in hazardous noise areas. If it is not possible to obtain the baseline prior to noise assignment, then employees shall undergo a baseline audiometric examination within 30 days of initial exposure to hazardous noise . During this 30-day period, employees shall wear personal HPDs, which reduce their exposure to 82 dBA TWA or below. When it is discovered that personnel have already been assigned to a position that may expose them to hazardous noise but have not yet had an audiometric examination, audiometry shall be conducted within 30 days of the discovery, and employees shall wear personal hearing protection that reduces their exposure to 82 dBA TWA or below.

(iii) Audiometric examinations shall include an audiogram, an otoscopic examination by an audiologist, physician, or Council on Accreditation for Occupational Hearing Conservation (CAOHC)-certified occupational hearing conservationist, unless otherwise appropriately trained, to determine any existing medical pathology of the ear, and an update to their medical history (occupational and personal) to document past noise exposure and other otopathological factors.

(iv) The employee shall have no apparent or suspected ear, nose, or throat problems that might compromise the validity of the audiogram. When an employee has an acute disease that may compromise the validity of the test, the audiogram shall be delayed until the condition has abated.

(v) At the time of the audiometric examination, exposure history shall be collected to include ototoxic medications and exposure to ototoxic substances .

(vi) If during a medical evaluation the employee is identified as , potentially unable to perform the job safely, the employee and employer shall receive a written notification of the requirement to perform an Ability and Risk Evaluation. The written notification shall include results of the medical and work history with special emphasis on the association of any health conditions that may impair ability to safely perform the work expected in the position held (hear commands or signals) or the ability to wear appropriate personal hearing protection equipment in a hazardous noise area.

(vii) Personnel suffering from acute diseases of the ear shall not be placed in hazardous noise areas until the condition has abated, particularly if such diseases preclude the wearing of hearing protectors.

(viii) Centers shall take all possible measures to assure that employees who have participated in the HCP medical surveillance program receive a final audiometric examination prior to termination of employment, transfer to duties not involving noise exposures, transfer to another installation, or retirement. An annual audiogram, if completed within 6 months of the termination, transfer, or retirement date, may be substituted for the final audiogram.

(ix) When employees at a Center retain their ?work role position? but change employers due to contract award to a new employer , all medical records applicable to hearing conservation shall follow them to their new employer , including their current baseline threshold.

(2) Audiometric testing:

(i) Audiometric testing shall be performed upon initial assignment, and annually thereafter, in accordance with 29 CFR 1910.95 Sections (g) and (h).

(ii) Audiometric testing shall be performed by, or overseen by, an audiologist or a physician knowledgeable in hearing conservation.

(iii) Personnel who conduct audiometric testing shall be familiar with the provisions of this section, and shall be

certified by the CAOHC, or be an audiologist.

(iv) All baseline audiograms shall be preceded by a period of at least 14 hours during which there is no known exposure to noise above 82 dBA TWA, on or off the job. Hearing protectors that lower workplace noise to the equivalent of 82 dBA TWA, using the appropriate noise-reduction rating, may be used as a substitute for the requirement that baseline audiograms be preceded by 14 hours without exposure to workplace noise.

(v) If the answer to ALL of the questions below is ?yes,? the STS shall be logged as an OSHA-recordable event in accordance with 29 CFR 1904.10:

a) Did an annual age-corrected audiogram reveal an STS (10 dB shift or greater, averaging 2k, 3k, and 4k Hz) relative to the baseline audiogram in one or both ears? (Age correction permitted.)

b) Is the employee's uncorrected hearing level (averaging 2k, 3k, and 4k Hz) 25 dB or greater above audiometric zero in the same ear as the STS? (Age correction NOT permitted.)

c) Is the hearing work related in the opinion of the medical and supervisory personnel?

(vi) If during a baseline audiogram the employee has a hearing profile equal to or worse than that listed in Table 2 below, the employee and employer shall receive a written notification of the requirement to perform an Ability and Risk Evaluation. The written notification shall include results of the medical and work history with special emphasis on the association of any health conditions that may impair ability to safely perform the work expected in the position held (hear commands or signals) or the ability to wear appropriate personal hearing protection equipment in a hazardous noise area.

Table 2

Frequency (Hz)	500	1000	2000	3000	4000	6000
Hearing Threshold Level (dB)	25	25	25	35	45	45

(3) Threshold Shifts:

(i) The STS may be computed using the age corrections described in OSHA 29 CFR 1910.95, Appendix F.

(ii) Each employee's annual audiogram shall be compared to his/her baseline audiogram to determine if the audiogram is valid and to determine if an STS has occurred.

(iii) The baseline of each ear shall be separately tracked.

(iv) A physician, audiologist, or CAOHC-certified occupational hearing conservationist shall perform the hearing test and the comparison.

(v) If an STS is identified and a confirmation audiogram is not performed within 30 days, the STS shall become a confirmed STS by default.

(vi) If the identified STS is followed by a confirmation audiogram and the confirmation audiogram does not confirm the STS, this second audiogram replaces the first one that suggested the STS.

(vii) If the identified STS is followed by a positive confirmation audiogram, the better of the two shall become the confirmed STS.

(viii) A physician or audiologist with hearing conservation experience shall review problem audiograms, including those showing an STS (either by confirmation with 30 days or by default) and shall determine whether there is a need for further evaluation. During the confirmation audiogram, the employee shall be examined by a physician, audiologist, or CAOHC-certified occupational health nurse for proper HPD fit.

(ix) When further evaluation is warranted, the employee shall be referred to an otolaryngologist or other qualified physician, or to an audiologist for further medical evaluation. See Section 4.9.3.l.(4), Referrals.

(x) A new baseline reference audiogram shall replace the original or previous baseline audiogram (in separate ears and not both ears, unless both ears meet criteria listed below) when:

a) The reviewing CAOHC-certified hearing conservationist determines that an STS is persistent on a retest (conducted no sooner than 6 months later). Unless an audiologist or physician determines and documents reasons for not revising the baseline, the baseline shall be revised to the lower (more sensitive) value for the average. Employees assigned a new baseline audiogram, as a result of an STS, shall receive an audiometric re-evaluation 6 months after this assignment to determine if a further STS has occurred.

b) A ?significant improvement? is shown if the average of thresholds at 2000, 3000, and 4000 Hz for either ear

shows an improvement of 5 dB or more from the baseline and the improvement is persistent in the next test. The baseline shall be revised to the lower (more sensitive) value for the average unless a physician or audiologist determines and documents reasons for not revising. Age corrections shall not be used when determining ?improvement.?

(xi) The employee, employer, and environmental health staff shall be notified of an STS in writing within 21 days of the determination of the STS.

(xii) Based on the best available information, the employer of an employee with an STS shall determine, in coordination with the physician or physician representative and the employer's health and safety representative, if the noise-induced STS is the result of occupational noise exposure.

(xiii) Where it has been determined that an employee has experienced an STS as a result of an occupational noise exposure:

a) The employee shall be examined by a physician or an audiologist for proper HPD fit.

b) HPDs shall be reevaluated for effectiveness and the employee shall be refitted as necessary with HPDs offering a greater sound attenuation.

c) The work environment(s) shall be investigated to determine if work practices or changes in equipment or procedures have increased the noise hazard and abatement actions shall be instituted, as necessary.

d) The work-related hearing loss shall be reported to the Center's mishap reporting system.

e) The employee shall be trained or retrained on the hazardous effects of noise and the need to use hearing protection.

f) Engineering controls shall be employed to reduce the potential for exposure to action level.

g) Administrative and work practices shall be reevaluated for effectiveness.

h) The employee shall be rechecked or refitted with hearing protectors, offering greater sound attenuation, if needed.

i) The employee's management and responsible safety and health office will be notified of the occurrence of an STS or other work-related hearing loss.

(xiv) When an OSHA-recordable STS has occurred, the employer shall record the condition as a hearing loss on the OSHA 300 Log and maintain the record in accordance with 29 CFR 1904, Recording and Reporting Occupational Injuries and Illnesses.

(xv) The Medical Director shall determine if reassignment to work in a low noise area is indicated to prevent further hearing impairment and shall advise the employer accordingly.

(xvi) The employer shall have ultimate authority and responsibility for employee reassignment.

(xvii) Where the same employee experiences any subsequent work-related STS as a result of occupational noise exposure, the work environment(s) shall be reevaluated. If the employee continues to work in the hazardous noise area(s), engineering and/or administrative controls shall be employed that reduce that employee's noise exposure to no more than 50 percent of what was previously allowed for that employee.

(4) Referrals:

(i) Employees shall be referred to an otolaryngologist or other physician knowledgeable in hearing conservation or to an audiologist based on the criteria in this section.

(ii) Where further medical testing or referrals are needed, the employee shall be notified of the reason for the testing or need for referral.

(iii) When the examining physician refers an employee to a specialist, communication of relevant medical data shall be provided to the specialist.

(iv) The following criteria are based upon the American Academy of Otolaryngology-Head and Neck Surgery referral criteria and shall be used for referral to a qualified physician or otolaryngologist for more comprehensive testing and/or treatment:

a) Average hearing level at 500, 1000, 2000, and 3000 Hz greater than 25 dB HTL in either ear (Baseline Audiogram).

b) Difference in average hearing threshold level between the better and poorer ears of more than 15 dB HTL at 500, 1000, and 2000 Hz (Baseline Audiogram).

c) Change for the worse in average hearing level in either ear compared to the baseline audiogram of more than 15

dB at 500, 1000, and 2000 Hz or more than 20 dB at 3000, 4000, and 6000 Hz (Periodic Audiograms).

d) Variable or inconsistent responses or unusual hearing loss curves (Periodic Audiograms).

e) History of ear pain; drainage; dizziness; severe, persistent tinnitus; sudden, fluctuating or rapidly progressive hearing loss; or a feeling of fullness or discomfort in one or both ears within the preceding 12 months (Any Audiogram).

f) Earwax accumulation sufficient to completely obstruct the view of the eardrum with otoscopy or foreign body in the ear canal.

g) The employee has failed any of the above criteria and has ear pain; drainage; dizziness; or severe, persistent tinnitus (Any Audiogram).

h) When an employee suspects that a medical pathology of the ear is caused or aggravated by the wearing of hearing protectors (Any Audiogram).

m. Impairment

The latest edition of the American Medical Association Guides to the Evaluation of Permanent Impairment shall be used as a guideline in determining hearing impairment.

n. HCP/Hazardous Noise Training:

(1) Each occupational hearing conservationist shall receive CAOHC certification training. A CAOHC refresher course shall be taken every 5 years, at a minimum.

(2) Occupational health personnel who conduct assessments shall receive initial training in their Center's hearing conservation program and in noise exposure hazard training.

(3) Employees enrolled in an HCP and their supervisors shall receive annual training in the hazards of noise exposure.

(4) Annual training in the hazards of noise exposure shall include, at a minimum:

(i) An overview or review of this section.

(ii) An overview or review of the 29 CFR 1910.95, their Center's and employer's HCP, and this section.

(iii) The effects of hazardous noise and ototoxic substances on hearing (including permanent hearing loss).

(iv) Identification of the hazardous noise sources in the employee's work areas.

(v) Factors that may contribute to hearing loss.

(vi) Noise-control principles.

(vii) An explanation of the audiometric testing procedure and the purpose of audiometric testing.

(viii) The employee's role and responsibilities in the HCP.

(ix) The purpose of HPDs including:

a) The advantages, disadvantages, and attenuation characteristics of various types of HPDs.

b) Instructions on selection, fitting, use, and care of HPDs.

c) The recommendation that employees use hearing protection whenever they are exposed to hazardous noise during off-duty activities (e.g., lawn mowing, use of firearms).

o. Other Considerations:

(1) Recordkeeping.

(i) Accurate HCP records shall be maintained as specified in the applicable records retention schedules in NPR 1441.1 and 29 CFR 1910.95 (m), Recordkeeping. Records kept shall include:

a) The Center's written HCP and subsequent revisions.

b) A comprehensive registry of all personnel placed in the HCP. *

c) Audiometric tests and records. *

d) Background sound pressure levels of audiometric test rooms.

e) Data and information concerning repair of audiometers.

f) Hazardous noise areas and noise levels recorded in those areas.

g) Survey and dosimetry results and recommendations. *

h) Data and information concerning calibration and repair of sound-measuring equipment.

i) The employee's most recent noise-exposure assessment.

j) Special noise studies.

k) Remedial actions recommended/taken.

l) Engineering controls installed.

m) Design operational and review results.

n) Training.

o) Hearing protector selection.

p) Documentation of other official HCP-related activities.

(ii) Items above marked with an asterisk (*) shall be maintained for at least 30 years.

(iii) Audiometric test records shall include, as a minimum:

a) Hearing threshold levels at 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz.

b) The audiometric reference level to which the audiometer was calibrated at the time of testing.

c) The date of the audiogram.

d) The name, employee number, and job classification of the employee tested.

e) The examiner's name and position.

f) The date of the last calibration of the audiometer.

(iv) Consistent with the requirements of the Privacy Act and the restrictions in the "Annual Notice and Amendment to Systems of Records," published in the Federal Register, copies of this section, 29 CFR 1910.95, "Occupational Noise Exposure Hearing Conservation Amendment Final Rule" and appendices, and any other records required by this section, shall be provided upon request to:

a) Employees and former employees and their representatives.

b) Representatives of the U.S. Department of Labor.

c) The National Institute for Occupational Safety and Health (NIOSH).

d) Occupational Health Program personnel.

(v) Audiograms and noise-exposure records shall be maintained as a permanent part of an employee's medical records.

(vi) When noise-exposure-measurement records are representative of the exposures of other individuals participating in the Hearing Conservation Program, and to the extent allowable by the Privacy Act, the range of noise levels and the average noise doses shall be made a permanent part of the medical records of those other individuals.

4.9.4 Authorities

a. 42 U.S.C. § 2473 (c) (1), Section 203 (c) (1) of the National Aeronautics and Space Act of 1958, as amended.

b. 5 U.S.C. § 552a, the Privacy Act of 1974, as amended.

c. 29 U.S.C. § 668, Occupational Safety and Health; Programs of Federal Agencies.

d. 29 CFR Part 1904.10, Occupational Injury and Illness Recordkeeping and Reporting Requirements.

e. 29 CFR Part 1910.95, Occupational Noise Exposure Hearing Conservation Amendment Final Rule.

f. 29 CFR Part 1960, Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters.

g. 29 CFR Part 1910.1020, Access to Employee Exposure and Medical Records.

h. 48 CFR Part 1823, Environment, Energy and Water Efficiency, Renewable Energy Technologies, Occupational

Safety, and Drug-Free Workplace.

i. EO 12196, Occupational Safety and Health Programs for Federal Employees, dated February 26, 1980.

4.9.5 References

a. NPD 1800.2B, NASA Occupational Health Program.

b. NPD 1810.2B, NASA Occupational Medicine Program.

c. NPD 1820.1B, NASA Environmental Health Program.

d. NPD 1840.1B, NASA Workers' Compensation Program.

e. NPR 1441.1D, NASA Records Retention Schedules.

f. NPR 8715.1, NASA Occupational Safety and Health Programs.

g. NPR 8621.1B, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping.

h. ANSI S1.4, Latest revision, Specification for Sound-Level Meters.

i. ANSI S1.11, Latest revision, American National Standard Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters.

j. ANSI S1.25, Latest revision, Specification of Personal Noise Dosimeters.

k. ANSI S3.1, Latest revision, Maximum Permissible Ambient Noise Levels for

Audiometric Test Rooms.

l. ANSI S3.6, Latest revision, Specification for Audiometers.

m. ANSI S3.20, Latest revision, Bioacoustical Terminology.

n. ANSI S3.44, Latest revision, Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment.

o. ANSI S12.6, Latest revision, Methods for Measuring the Real-Ear Attenuation of Hearing Protectors.

p. ANSI S12.19, Latest revision, Measurement of Occupational Noise Exposure.

q. NHCA Professional Guide for Audiometric Baseline Revision. (Latest revision.)

r. NIOSH Criteria for a Recommended Standard, 1998.

s. American Medical Association, Guides to the Evaluation of Permanent Impairment.

t. Suter, A. (2002), Hearing Conservation Manual, Council for Accreditation in Occupational Hearing Conservation, fourth edition.

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